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Analysis of financial parameters for a combined photovoltaic/ LED intelligent lighting low voltage distributed generation

Filip Carlea[a]*, Dan Ilie Teodoreanu[a], Iulian Iancu[a]

Centre for Renewable Energy and Energy Efficiency, Casa Academei, Calea 13 Septembrie, 13, code 050 711, Bucureşti, România

Abstract

Romania has a good natural potential for all renewable sources: solar, wind, biomass, geothermal. To reach at economic practicability of renewable energy sources (RES), Romania needs to accelerate the development of the national RES industry and to remove several legal and administrative barriers. To develop the potential of RES and reach the targets, Romania has established a legal and institutional framework appropriate for promoting the use of renewable energy sources. According to the Directive 2009/28/EC on the promotion of the use of energy from renewable sources the target for the share of energy from renewable sources in gross final consumption of energy in the year 2020 for Romania is 24%. In Romania there is a mandatory quota system accompanied by Green Certificates (GC) system. For the period 2020-2030, the quotas shall be set through a governmental decision and cannot be lower than the quota for 2020. The research is about of renewable energy sources implemented by a photovoltaic system in a pilot project and the electricity used in in-house consumption. The objectives consist in producing of electricity from renewable sources (solar-photovoltaic sources), environment protection, using the new technology and energy efficiency having in attention for better human life.

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Keywords: photovoltaic energy, energy efficiency, renewable energy, solar radiation, green certificate;

* Corresponding author. Tel.: +0721082743.
E-mail address: filip_carlea@yahoo.com

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1. Introduction

This paper presents a financial analysis of a project for Large public and Commercial buildings with applications of integrating a photovoltaic system and energy efficiency method. The first part presents a specific interest in House Academy, a building with a relatively large inner and outer surface. Area available for installation on the roof of photovoltaic modules is approximately 3,500 m^2. Next it shows the input data for this analysis, namely energy, meteorological data of the location, parameters of the PV system and lighting system LED.In the chapter Results are presented the financial parameters calculations as internal rate of return (IRR), net present value (NPV) of the investment and the investment recovery time (TR) for two typical applications (Case A using European structural funds primarily for public buildings and Case B with accessing bank funds especially for commercial buildings). The last chapter is devoted to sensitivity and risk analysis for the two cases and the performance parameters studied.

2. System description

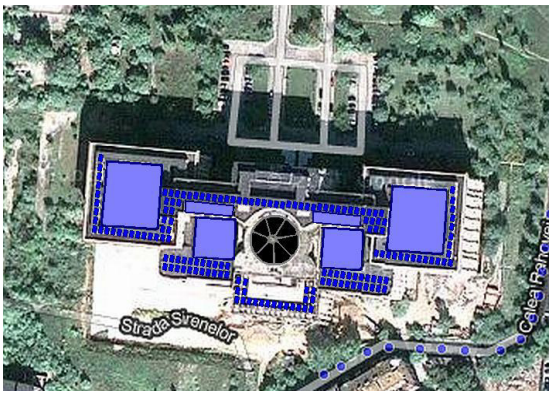


Fig. 1. Academy Building. - view of the top building

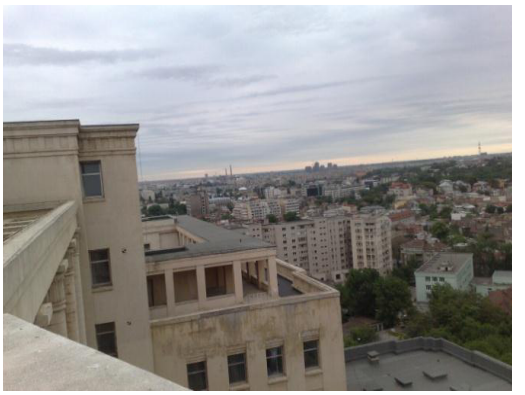


Fig. 2. Academy Building - view to the roof and façade (*semitransparent PV*)

The system has to main components:

2.1. *PV Systems based on different cell technologies*: monocristalline silicon, polycrystalline silicon modules installed on the roof of a big public building (Figure 1). Semitransparent modules will be integrated into the building (Figure 2).

2.2. *The energy efficiency component*: Intelligent LED lighting inhouse and outdoor (Figure 3 and Figure 4).

Fig.3. Academy Building. - South View

Fig. 4. Academy building - Nord View

3. Input Parameters

3.1. Meteorological parameters are presented - Table No. 1

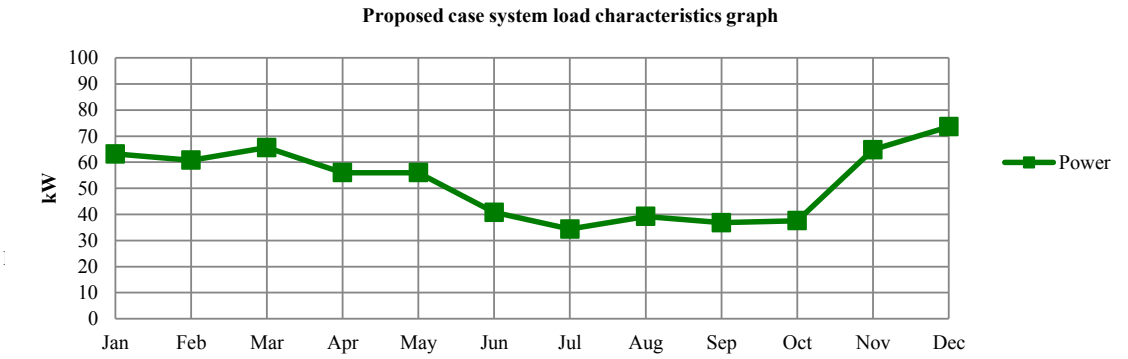
	Unit	Climate data location	Project location
Latitude	°N	44.5	44.5
Longitude	°E	26.1	26.1
Elevation	m	91	91

Table 1. Site location and Meteorological Parameter (NASA and RET Screen Data)

Month	Air temperature	Relative humidity	Daily solar radiation	Atmospheric pressure	Wind speed
	°C	%	kWh/m²/d	kPa	m/s
January	-2.4	88.3%	1.44	100.9	2.4
February	-0.1	82.3%	2.30	100.8	2.7
March	4.8	75.0%	3.40	100.7	2.8
April	11.3	71.7%	4.85	100.3	2.6
May	16.7	69.1%	6.04	100.3	2.1
June	20.2	71.0%	6.55	100.2	1.7
July	22.0	69.4%	6.49	100.3	1.6
August	21.2	69.7%	5.77	100.4	1.4
September	16.9	74.5%	4.40	100.7	1.5
October	10.8	81.1%	3.06	101.0	1.7
November	5.2	86.9%	1.36	100.9	2.2
December	0.2	88.9%	0.95	100.8	2.2
Annual	10.6	77.3%	3.89	100.6	2.1
Measured at					10.0m

3.2. *Energy efficiency parameters are presented in figure 5*

Proposed case energy efficiency measures		
End-use energy efficiency measures	%	20
Net peak electricity load	kW	699
Net electricity	MWh	551



3.2. The specific parameters for the PV system are presented in the Table 2

Table 2. Parameters of the PV system

Resource assessment		
Solar tracking mode		Fixed
Slope	°	10.0
Azimuth	°	0.0
Annual solar radiation - horizontal	MWh/m²	1.42
Annual solar radiation - tilted	MWh/m²	1.51
Photovoltaic		
Type		Poly-Si
Power capacity	kW	300.00
Efficiency	%	15.3%
Nominal operating cell temperature	°C	45
Inverter		
Efficiency	%	98.0%
Capacity	kW	300.0
Summary		
Capacity factor	%	14.5%
Electricity delivered to load	MWh	359.839
Electricity exported to grid	MWh	20.476
Electricity rate - proposed case	€/MWh	120
Full power capacity output		380

3.4. *The GHG emission reduction are presented in the Table 3*

Table 3. Calculation of the net quantity of GHG reduction annually (CO_2 equivalent)

	Fuel mix	Fuel	GHG emission	GHG emission
Fuel type	%	MWh	tCO2/MWh	tCO2
Electricity	100.	709	0.478	338.8
Total	100.	709	0.478	338.8
	Fuel mix	Fuel	GHG emission	GHG emission
Fuel type	%	MWh	tCO_2/MWh	tCO_2
Solar	66.5	380	0.000	0.0
Electricity	33.5	191	0.478	91.4
Total	100.	572	0.160	91.4
Electricity exported to grid	20MWh	0	0.478	0.0
			Total	91.4

		Proposed	Gross annual	GHG credits	Net annual
tCO_2	tCO_2	tCO_2	%	tCO_2	
338.8	91.4	247.5		247.	

3.5. *Financial Parameters in the two cases*:

- Case A: the funds are coming from European structural funds and the contribution of the owner is 10% from the total capital invested. The total produced PV energy is auto consumed. The financial input data are presented in the Table 4.
- Case B: the capital of investment is the same. The contribution of the owner is 90% and Dept 10%. The owner receives a Feed in Tariff for the total PV energy produced.

Table 4. Financial parameters (Case A)

General		
Inflation rate	%	2.5%
Discount rate	%	5.0%
Project life	yr	20
Finance		
Incentives and grants	€	630.000
Income tax analysis		
Effective income tax rate	%	16.0%
Electricity export income		
Electricity exported to grid	MWh	20
Electricity export rate	€/MWh	120.00
Electricity export income	€	2,457
Electricity export escalation rate	%	2.5%
GHG reduction income		
Net GHG reduction	tCO2/yr	247
Net GHG reduction - 20 yrs	tCO2	4,949
GHG reduction credit rate	€/tCO2	10.00
GHG reduction income	€	2,475
GHG reduction credit duration	yr	20
Other income (cost)		
Energy	MWh	-191
Rate	€/MWh	120.000
Other income (cost)	€	-22,920
Duration	yr	20
Escalation rate	%	2.5%
Clean Energy (CE) production income		
CE production	MWh	360
CE production credit rate	€/kWh	0.120
CE production income	€	43,181
CE production credit duration	yr	20
CE production credit escalation rate	%	2.5%

Table 5. Financial parameters (Case B)

Discount rate	%	5.0%
Finance		
Incentives and grants	€	0
Debt ratio	%	10.0%
Debt	€	70,400
Equity	€	633,600
Debt interest rate	%	5.00%
Debt term	yr	10
Debt payments	€/yr	9,117
Income tax analysis		
Effective income tax rate	%	16.0%
Electricity export income		
Electricity exported to grid	MWh	20
Electricity export rate	€/MWh	120.00
Electricity export income	€	4,914
GHG reduction income		
GHG reduction credit rate	€/tCO_2	10.00
GHG reduction income	€	2,475
GHG reduction credit duration	yr	20
Net GHG reduction - 20 yrs	tCO_2	4,949
Other income(cost)		
Energy	MWh	-191
Rate	€/MWh	120.000
Other income (cost)	€	-22,920
Duration	yr	20
Escalation rate	%	2.5%
Clean Energy (CE) production income		
CE production	MWh	380

CE production credit rate	€/kWh	0.240
CE production income	€	91,276
CE production credit escalation rate	%	2.5%

4. Results.

4.1. The calculated financial performances are presented in the Table 6 for Case A and Table 7 for Case B.

Table 6. Financial performances and Cash flow for the case A.

Pre-tax IRR - equity	%	34.5%
After-tax IRR - equity	%	12.0%
Equity payback	yr	8.0
Net Present Value (NPV)	€	132,949
Annual life cycle savings	€/yr	10,668
Benefit-Cost (B-C) ratio		1.19

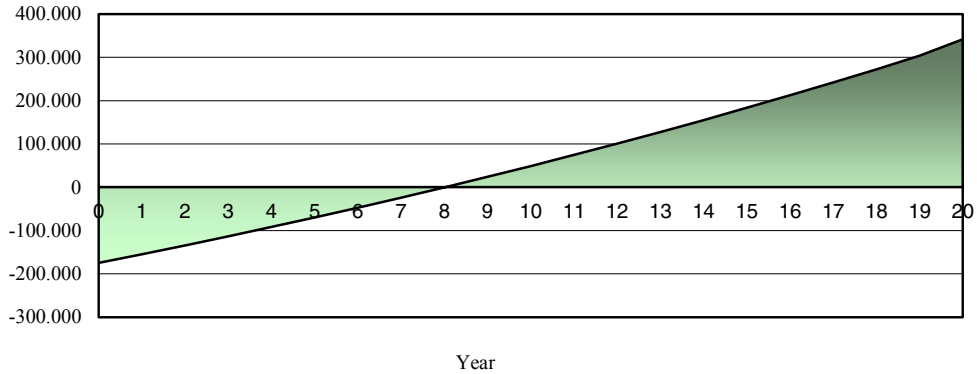


Fig. 1. Cumulative cash flows graph

Table 7. Performance parameters and Annual Cash flow for the Case B

Pre-tax IRR - equity	%	12.0%
After-tax IRR - equity	%	8.8%
Equity payback	yr	8.5
Net Present Value (NPV)	€	179,612
Annual life cycle savings	€/yr	14,413
Benefit-Cost (B-C) ratio		1.28

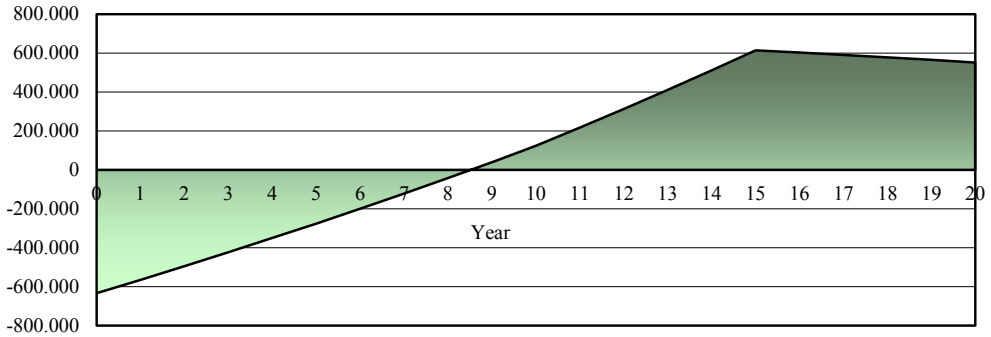


Fig 2. Cumulative cash flows graph

4.2. Sensitivity analysis and Risk

In the Tables 8 and 9 are presented sensitivity analysis for the Case A and B (the red cells are outside of the recommended performances). Each table shows what happens to the selected financial indicator (NPV) when two parameters (initial costs and O&M, initial cost and CE credit rate, initial cost and Net GHG reduction) are varied by the maximum 50% percentage.

Table 8. Sensitivity analysis for NPV - Case A

Perform analysis on		Net Present Value (NPV)				
Sensitivity range		50%				
Threshold	0	€				
				Initial costs		€
CE production credit rate		352,000	528,000	704,000	880,000	1,056,000
€/kWh		-50%	-25%	0%	25%	50%
0.060	-50%	33,056	-142,944	-318,944	-494,944	-670,944
0.090	-25%	234,268	58,268	-117,732	-293,732	-469,732
0.120	0%	484,949	308,949	132,949	-43,051	-219,051
0.150	25%	807,253	631,253	455,253	279,253	103,253
0.180	50%	1,201,180	1,025,180	849,180	673,180	497,180
				Initial costs		€
O&M		352,000	528,000	704,000	880,000	1,056,000
€		-50%	-25%	0%	25%	50%
1,000	-50%	498,218	322,218	146,218	-29,782	-205,782
1,500	-25%	491,584	315,584	139,584	-36,416	-212,416
2,000	0%	484,949	308,949	132,949	-43,051	-219,051
2,500	25%	478,314	302,314	126,314	-49,686	-225,686
3,000	50%	471,680	295,680	119,680	-56,320	-232,320
				Initial costs		€
Net GHG reduction - credit		352,000	528,000	704,000	880,000	1,056,000
tCO2		-50%	-25%	0%	25%	50%
2,475	-50%	468,531	292,531	116,531	-59,469	-235,469
3,712	-25%	476,740	300,740	124,740	-51,260	-227,260
4,949	0%	484,949	308,949	132,949	-43,051	-219,051
6,186	25%	493,158	317,158	141,158	-34,842	-210,842
7,424	50%	501,367	325,367	149,367	-26,633	-202,633

Table 9. Sensitivity analysis for Net Present Value - Case B

Perform analysis on		Net Present Value (NPV)				
Sensitivity range		50%				
Threshold	0	€				
				Initial costs		€
CE production credit rate		352,000	528,000	704,000	880,000	1,056,000
€/kWh		-50%	-25%	0%	25%	50%
0.120	-50%	-184,934	-360,250	-535,566	-710,882	1,196,259
0.180	-25%	113,057	-62,259	-237,575	-412,891	-588,208
0.240	0%	530,244	354,928	179,612	-412,891	-171,020
0.300	25%	1,066,628	891,312	715,996	540,679	-171,020
0.360	50%	1,722,208	1,546,892	715,996	1,196,259	1,020,943
				Initial costs		€
O&M		352,000	528,000	704,000	880,000	1,056,000
€		-50%	-25%	0%	25%	50%
1,000	-50%	543,934	368,618	341,239	17,985	-157,331
1,500	-25%	543,934	361,773	186,457	17,985	-164,176
2,000	0%	530,244	361,773	179,612	4,296	-164,176
2,500	25%	523,400	348,084	179,612	-2,549	-177,865
3,000	50%	523,400	341,239	165,923	-2,549	-184,710
				Initial costs		€
Net GHG reduction - credit duration		352,000	528,000	704,000	880,000	1,056,000
tCO2		-50%	-25%	0%	25%	50%
2,475	-50%	513,307	337,991	162,675	-12,641	-187,958

3,712	-25%	521,776	346,460	171,143	-4,173	-179,489
4,949	0%	530,244	354,928	179,612	4,296	-171,020
6,186	25%	538,713	363,397	188,081	12,764	-162,552
7,424	50%	547,182	371,865	196,549	21,233	-154,083

In the figure 8, 9,10 and 11 are presented the evaluation of the Risk. The evaluation is made with 10% the uncertainty associated with a number of key input parameters and to evaluate the impact of this uncertainty on NPV.

The risk analysis is performed using a RET Screen Program Monte Carlo simulation that includes 500 possible combinations of input variables resulting in 500 values of NPV. The risk analysis allows the user to assess if the variability of the financial indicator is acceptable, or not, by looking at the distribution of the possible outcomes.

- Risk analysis for NPV - Case A

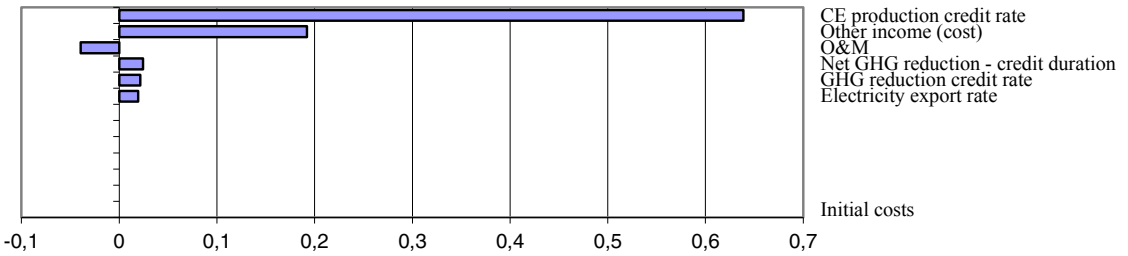


Fig. 3. Impact - Net Present Value (NPV). Relative impact (standard deviation) of parameters

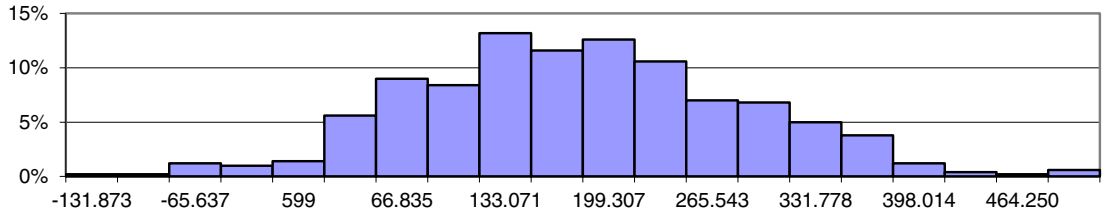
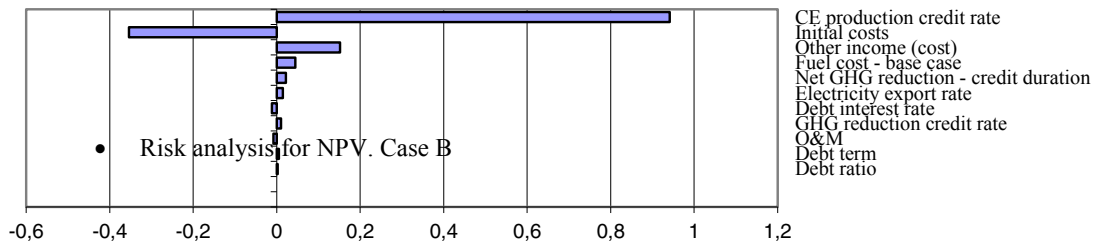


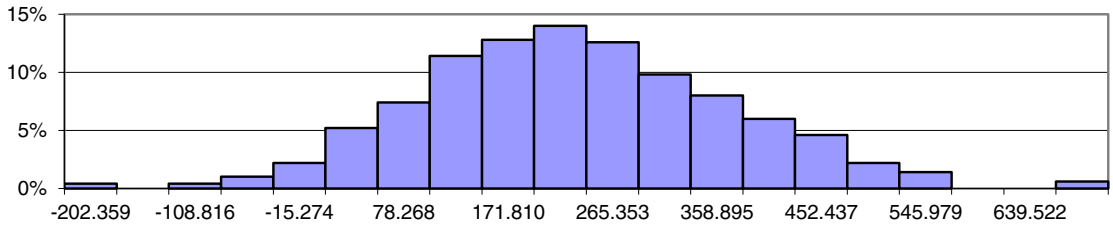
Fig. 4. Distribution Net Present Value

Median	€	109,511
Level of risk	%	10.0%
Minimum within level of confidence	€	-187,014
Maximum within level of confidence	€	526,180



- Risk analysis for NPV. Case B

Fig. 5. Impact – Net Present Value (NPV). Relative impact (standard deviation) of parameters



Median	€	164,461
Level of risk	%	10.0
Minimum within level of confidence	€	-278,851
Maximum within level of confidence	€	792,905

Conclusions

The financial evaluation of the two methods of investment in a mixed technology Renewable Energy (RES) and Energy Efficiency has the following results: both Cases A and B have financial evaluation positive;

- the Case A have better: IRR (internal rate of return) =12%, the payback time also better: 8.0 Years;
- the Case B has better performances for NPV: 179,612 and the Benefit/Cost ratio = 1.28;
- the most important parameters are the Investment and the subventions;
- in the case B presented IRR is 8.8% and TR is 8.5 years, for a contribution of 90% of own source. For values of 50% own contribution IRR values are 10% and TR are 9 years. This parameter has a small influence on the IRR. IRR depends strongly on the value of subsidies but remains positive for the regulated price of MWh over 195 € and 5% IRR and 10.6 years TR.

Both cases will be really in the next years in Romania. The case B is based on the future politics of the European Union and Romania in growing the contribution of RES in the total Value of the Structural Funds

Energy Efficiency: the development of Distributed Generation at Low Voltage will be also developed (Smart Grid Politics, Saturation of the injection of RES in the High Voltage Grids) and in this situation also Case B will be favorable for private and public-private investment activities.

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